The Impact of Inflation Volatility on an Enterprise's Innovation Strategy

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Abstract*: The objective of the study was to determine the effect of inflation volatility on an enterprise's innovation strategy. The study showed that increasing inflation leads to a decrease in the stationary level of potential output, as well as to a decrease in the rate of economic growth in the process of transition to a stationary state. A formula is proposed for calculating the total effect of inflation on the level of enterprise output. The negative impact of the inflation rate on the welfare of economic agents was revealed, which is expressed in the fall in their equilibrium consumption level. Higher-income countries have been shown to suffer more from high inflation than poorer countries. All conclusions made in the analysis of the dynamic model of the impact of inflation on potential output are verified based on econometric modelling using methods and models for panel data: models with fixed effects, models with random effects, and a generalized method of moments. Moreover, the obtained empirical results are stable concerning changes in the specification of the equation and estimation methods.

Keywords* : *Enterprise, Inflation, Innovation, Strategy, Volatility.

I. INTRODUCTION

Currently, the two main target options in the world are the exchange rate and inflation. The use of a fixed exchange rate has been and remains the most popular model, however, the number of countries that use it is gradually decreasing. Inflation targeting, in turn, is the second most frequent policy option with a clear nominal anchor, and the popularity of this regime among countries around the world is growing steadily [1-3]. There is a significant gap between the capabilities of existing models, which mainly rely on the neutrality of money in the long term and the needs of monetary policy institutions that need to understand the mechanisms of its impact on the long-term dynamics of macroeconomic variables.

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II. ENTERPRISE'S INNOVATION STRATEGIES

An essential characteristic of the innovation process is its focus, development in a strictly defined and predetermined direction. From this premise, the need arises for the recognition of the strategic thinking of enterprise management and the manageable overcoming of barriers to innovation [4-6].

Besides, the process of innovation is challenging to describe in terms of anyone change. In most cases, this is a set of measures that cause various transformations in enterprises. This process is developing very complex and dynamic, with the simultaneous influence of the whole combination of external and internal factors on it. And only at some enterprises, the updating is carried out by a pre-thought out program [7]. Most often, an initial innovation (for example, the acquisition of equipment) becomes the detonator of a whole chain of changes in the organization of an enterprise, in labor relations, in relations with suppliers and consumers of products. The materials of the cases studied provide quite convincing evidence that the initiators of innovations do not always imagine the scale of subsequent changes, are not always ready for them and are not always able to cope with them.

The diversity of innovative strategies is largely due to the initial differences between enterprises and the variability of the conditions in which they have to operate.

The nature of the innovation process is dialectical. On the one hand, it is discrete: we find ourselves at the enterprise and describe the situation that developed at a certain point in time. On the other hand, through the perception of the participants, we can restore the retrospective, the development of events, and during the long-term observation describe the sequence of steps, the change of state [8-10]. Despite the variety of individual "trajectories" of enterprise behaviour in changing conditions, we can talk about innovative strategies as a generalization of multiple isolated cases and understand them as a regular change in the state of the enterprise. The most significant, in our opinion, are two reasons for highlighting problem situations (conditions) in which enterprises find themselves in a given period. The first foundation is resources. When analyzing the innovative mechanism in the section "Evolution of the social mechanism of innovation" their composition is examined in detail. For our task, it is essential that, firstly, the resources have a complex structure: financial, material, informational, social, etc. Secondly, they can partially be interchangeable (convertible) [11-15].

So, production facilities or equipment can be sold or leased, i.e. become financial resources. Highly qualified personnel do not require additional training in the implementation of new technology (financial resources are saved), can serve as a source of innovative ideas and activity. In the case of appropriate motivation, employees may for some time "suffer" a relative decrease in the level of wages (there is a "conversion" of social resources into financial), etc. Therefore, in the future, we will talk about the absence, limitation or sufficiency of resources:

- ***Lack of resources*** means that the enterprise can support mainly (and often with great difficulty) its current production activities. Innovative activity is carried out at such an enterprise through the updating of equipment that has exhausted its resource and fails; minor structural changes, reorganization of management, etc.
- ***Limited resources*** allow the enterprise to carry out innovations in a "step-by-step" mode. At the same time, their "complexity" is lost, they line up in a "chain", and innovative activity is episodic, "flickering" in nature.
- In the case of possession (or receipt) of ***sufficient resources***, the enterprise can carry out full-scale, comprehensive transformations.

The second basis for the classification of problem situations is the characteristic of demand for products manufactured by the enterprise. A fundamental problem for most traditional enterprises is a sharp decline in need during the transition from an administrative command (planned) to a market economy. Such a decrease in demand primarily initiates the innovative activity of enterprises. In some cases, high demand (as a result of the monopoly position of the enterprise on the market) reduces innovative activity. Here, as in the case of resources, it is advisable to distinguish three situations:

- ***high demand*** - equal to or exceeds the capabilities of the enterprise and allows you to improve its economic situation and increase resources;
- ***average demand*** - less than the capabilities of the enterprise; the volume of product sales does not significantly improve the economic situation and quickly increase the resources of the enterprise;
- ***weak demand*** - there is practically no demand for the company's products, which worsens the financial situation and gradually reduces the company's resources.

In relation to each of the grounds that we have chosen for the analysis of innovative strategies, there is a trend that forces enterprises to show innovative activity sooner or later. Thus, resources (in a static state) are gradually "depreciating": buildings and equipment are ageing, inflation is "eating up" money accumulations, technologies, knowledge, management methods, etc. are becoming obsolete. Demand for products (as a result of the activities of competitors and market development) is falling, or the economic efficiency of the selected market segment is decreasing. As a result of these trends, the enterprise is not in a stable environment ("lake"), but in a changing business situation ("river") and is forced to adapt to it ("row").

The combination of three options for demand with three options for providing resources gives nine typical situations in which an enterprise may find itself (Fig. 1). Each problematic situation (state of the enterprise) can be associated with a predominant innovative strategy, which is aimed at solving problems and changing the state in a more favourable direction: increasing resources and increasing demand.

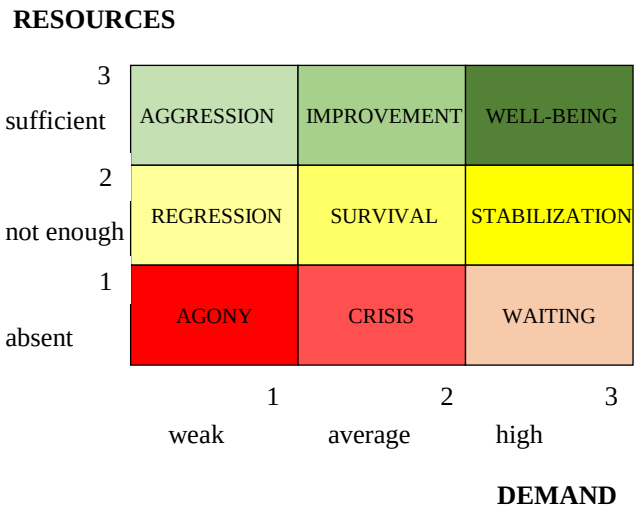

Fig. 1. Nine typical enterprise situations

The lack of resources puts any enterprise on the brink of bankruptcy - therefore, in any market condition, the main goal will be to search (or accumulate) resources for the development, updating of production, etc. In the absence of demand for products, management is considering options for the liquidation of the enterprise.

However, the proposed option does not take into account the impact of inflation on the innovative strategy of the enterprise.

III. METHODOLOGY

The methodology for the econometric assessment of the relationship between inflation and output is based on the approach used by Hansen [16], who proposed a general method for estimating threshold regressions. Threshold regression refers to a model in which the effect of the explanatory variable on the dependent variable differs depending on whether the value of the explanatory variable is higher or lower than a certain threshold level. In other words, there are two (or more) modes of action of the regressor on the dependent variable. Moreover, the threshold level itself is also unknown and is estimated in the course of econometric modelling. Formally, the corresponding model can be represented as follows:

$$yi = \beta 1 * zi * I(xi < \gamma) + \beta 2 * zi * I(xi \geq \gamma) + \alpha * ci + \varepsilon i \quad (1)$$

where y is the explained variable;

z is the vector of explanatory variables, the effect of which on the explained variable depends on the mode;

x - threshold variable responsible for the current mode;

γ - threshold level;

I - indicator function equal to unity if the inequality indicated in brackets is true and equal to zero otherwise;

c - vector of control variables, the effect of which does not depend on the current mode

As a dependent variable, we used the smoothed GDP growth rate (yit variable) calculated using a five-year moving average. Smoothing was carried out to neutralize short-term cyclical fluctuations in GDP and to be able to analyze the long-term effects of the current monetary policy to combat inflation.

We evaluated the model parameters:

$$yit = \beta 0 + \beta 1 * (1 - di,t) * \pi i,t + \beta 2 * di,t * \pi i,t + \gamma * ci,t + ai + \varepsilon it \quad (2)$$

where cit is the vector of control variables, as control variables, the share of investments in GDP and the population growth rate were used. The choice of control variables is due, firstly, to the fact that most of our predecessors used them, and secondly, to the fact that, in accordance with all standard models of economic growth, long-term GDP is determined by the number of resources available to the economy, primarily the amount of labour and capital.

Note that:

εit is random model errors;

ai - country effects;

$\pi i,t$ is the inflation rate in annual terms, smoothed over a five-year moving average;

$di\ t$ is a variable characterizing the excess of the inflation threshold: $dit = 1$ for $\pi it > \pi *$ and $dit = 0$ for $\pi it \leq \pi *$;

π^* is the threshold inflation rate. As can be seen from the specification of the equation, it is assumed that when inflation exceeds the threshold level, a structural shift occurs in the effect of inflation on output. The parameter π^* was also estimated during the simulation.

Since the inclusion of this parameter in the model makes it non-linear, the model was evaluated using a non-linear least-squares method. This was done as follows: π^* values were sequentially sorted with a one per cent step. For each cost in the framework of the model with fixed effects, equation (1) was estimated, and the corresponding sum of squared residuals was calculated. The model for which the value of the sum of the squares of the residues was minimal was chosen as the best.

The use of a model with fixed effects is due to the fact that this approach allows us to take into account the specific country features of each of the objects in the sample and to avoid the potential bias in the estimates of the coefficients caused by ignoring these features in the simulation. Thus, fixed effects make it possible to take into account those features of countries that do not change over time or change very slowly: specific cultural variables, the quality of institutions, the initial level of welfare, etc. Therefore, the inclusion of fixed effects makes it unnecessary to take into account in the vector of control variables those factors that were used by some authors of previous studies when applying alternative methods for estimating coefficients (for example, methods for analyzing spatial samples) and which do not change over time — for example, the level of GDP per capita in the initial period of time.

With this specification of the equation, coefficient β1 characterizes the effect of low (below the threshold level) inflation on growth, while coefficient β2 characterizes the effect of high inflation.

The results of evaluating the regression equation using a model with fixed effects, a model with random effects, as well as a simple complete regression without taking into account country effects (pooled OLS) in accordance with the described methodology are presented in Table 1. As can be seen from the table, the estimated value of the threshold inflation rate for models with fixed and random effects was equal to eight per cent. An estimate of the coefficient β1 is statistically insignificant. This suggests that inflation below the threshold level does not affect the rate of economic growth.

Table- I: The results of evaluating models of the impact of inflation on economic growth

Regressor	Model 1	Model 2	Model 3
Evaluation Method	FE	RE	OLS
Inflation Rate Below Threshold	0.04 (0.03)	0.04 ** (0.02)	0.05 (0.03)
Inflation Rate Above Threshold	- 0.02 *** (0.005)	- 0.014 *** (0.001)	- 0.009 *** (0.003)
Share of investment in GDP	0.13 *** (0.02)	0.13 *** (0,00)	0.12 *** (0,01)
Population growth rate	0.44 *** (0.13)	0.44 *** (0.04)	0.46 *** (0.09)
Constant	- 0.01 (0,01)	- 0.01 (0.02)	- 0.005 (0.004)
Country effects	Yes	Yes	No
Threshold inflation rate	8%	8%	8%
R^2	0.41	–	0.24
R^2-within	0.19	–	–
P-value of the test for the absence of individual effects	0.00	0.00	–
Hausman test P-value	–	0.00	–
Number of observations	4,678	4,678	4,678

Notes: Robust standard errors are indicated in parentheses under the coefficient estimates. Symbols ** and *** mean significance at five and one percent levels, respectively.

Model 1 was obtained as a result of using fixed effects, model 2 - random effects, model 3 - simple complete regression without taking into account country effects (pooled OLS). Column R^2 for model 1 indicates LSDV-R^2

Additionally, to verify the stability of the results, models were also evaluated in which the same specification was used as in Table 1, taking into account the addition of dummy time variables (the so-called bidirectional models with fixed and random effects). These additional models are presented in Table 2. It can be seen from it that the numerical values of the parameters of interest to us change insignificantly, and the conclusions about their significance (or insignificance) remain unchanged, which confirms the stability of our results.

Table- II: The results of evaluating models of the impact of inflation on economic growth, taking into account temporary effects.

Regressor	Model 1	Model 2	Model 3
Evaluation Method	FE	RE	OLS
Inflation Rate Below Threshold	0.04 (0.03)	0.04 ** (0.02)	0.05 (0.03)
Inflation Rate Above Threshold	- 0.014 *** (0.005)	- 0.012 *** (0.001)	- 0.008 *** (0.003)
Share of investment in GDP	0.13*** (0.02)	0.13*** (0,00)	0.12*** (0,01)
Population growth rate	0.43*** (0.13)	0.45*** (0.04)	0.48*** (0.09)
Constant	- 0.01 (0,01)	- 0.01 (0.02)	- 0.005 (0.004)
Country effects	Yes	Yes	No
Temporary effects	Yes	Yes	Yes
Threshold inflation rate	8%	8%	8%
R^2	0.44	–	0.29
R^2-within	0.24	–	–
P-value of the test for the absence of individual effects	0.00	0.00	–
Hausman test P-value	–	0.00	–
Number of observations	4678	4678	4678

To eliminate the possible endogeneity of the regressors, a model specification was also evaluated in which all explanatory variables entered the equation with a lag in one period. Evaluation of this model led to results similar to those of the base specification. This is an indirect argument in favour of the fact that in the basic specification of the model, coefficient estimates for the variables of interest to us do not suffer from insolvency caused by their endogeneity.

An alternative point of view is that in practice, a situation is possible when the inflation rate is stably high, that is, inflation can be characterized by a high absolute level, but low volatility. Therefore, it seems important to answer the question: is high inflation really associated with its high volatility?

We evaluate the parameters of a model in which inflation volatility is regressed to the inflation rate and its lags, as well as, possibly, to its own lagged value as control variables, as well as fixed country effects. Inflation volatility at time t was measured as the sample standard deviation of inflation calculated over five periods (from period t - 4 to period t).

After that, we test the hypothesis that there is no long-term dynamic effect of the effect of inflation on its volatility. In other words, we examine the zero of the long-term dynamic inflation multiplier. Technically, this means experimenting with the Wald test the hypothesis that the sum of the coefficients for the variables characterizing the inflation rate is zero.

Some specifications were considered, which differed among themselves by the inclusion or non-inclusion of the lagged value of the dependent variable in the right side of the equation, as well as by the set of lags of the variable inflation rate included in the equation. The evaluation results are shown in Table 3.

Table- III: The results of evaluating models of the effect of inflation on its volatility. *Dependent Variable: Inflation Volatility*

Regressor	Model 1	Model 2	Model 3	Model 4
Inflation volatility with lag in one period	–	–	0.94*** (0,00)	0.94*** (0,00)
Lag inflation 1 period	0.82*** (0,01)	0.82*** (0,01)	0.42*** (0,00)	0.42*** (0,01)
Inflation with a lag of 2 periods	- 0.20*** (0,01)	- 0.20*** (0,01)	- 0.32*** (0,00)	- 0.32*** (0,01)
Inflation with a lag of 3 periods	0.22*** (0,01)	0.22*** (0,01)	0.08*** (0,00)	0.08*** (0.02)
Inflation with a lag of 4 periods	0.08*** (0,01)	0.09*** (0,01)	- 0.02*** (0,01)	- 0.02 (0.014)
Inflation with a lag of 5 periods	0.05*** (0,01)	0.05*** (0,01)	- 0.08*** (0,00)	- 0.08*** (0,01)
Control variables	Yes	Yes	Yes	Yes
Country effects	Yes	Yes	Yes	Yes
Temporary effects	No	Yes	No	Yes
R2-within	0.99	0.99	0.99	0.99
P-value of the test for the absence of individual effects	0.00	0.00	0.00	0.02
Long-term dynamic inflation multiplier	0.98	0.98	1.11	1.10
P-value of the test for equality to zero of the sum of coefficients for inflation variables	0.00	0.00	0.00	0.00
Number of observations	4551	4551	4551	4551

*Notes: Robust standard errors are indicated in parentheses under the coefficient estimates. Symbols ** and *** mean significance at five and one per cent levels, respectively.*

IV. RESULT AND DISCUSSION

The model shows that increasing inflation leads to a decrease in the stationary level of potential output, as well as to a decrease in the rate of economic growth in the process of transition to a stationary state. This effect occurs due to the action of two channels:

1. ***The channel of capital***. The increase in inflation leads to an increase in the costs of the menu, which reduces the profit of the enterprise, and, therefore, reduces the optimal stock of capital and investment. This, in turn, leads to a decrease in potential output. Also, rising inflation leads to increased volatility of inflation, which increases the level of uncertainty faced by firms and also makes investments less profitable.

2. ***The channel of labour***. Excessive (above a certain optimal level) increase in inflation leads to a decrease in the real assets of households, which reduces their incentives to work and encourages them to reduce labour supply, which, in turn, leads to a drop in the equilibrium level of output. It is shown that the marginal effect of inflation on potential output through the capital channel increases with increasing inflation, that is, increasing inflation from zero to ten per cent reduces output not as much as increasing inflation from ten to twenty per cent in annual terms.

At the same time, at low (close to zero) inflation rates, the negative effect of the capital channel on real GDP is less significant, and the impact of the labour channel can even be positive.

Thus, summing up the effects of the two channels of the influence of inflation on potential output, we can conclude that at low inflation rates, an increase in the general price level has either a weak negative or even positive effect on output (depending on which effect of the two channels prevails). However, in conditions of high inflation, a further increase in the general price level clearly has a negative impact on potential GDP. The resulting output is illustrated in Table 4.

Table- IV: Channels of inflation impact on potential output

Channel exposure	Impact of increased inflation on potential output	
	Low inflation	High inflation
Capital channel	Negative impact	Negative impact
Labour channel	Positive impact	Negative impact
Overall effect	Not determined	Negative

Analytically, the total effect of inflation on output can be approximated by the following formula:

$$\bar{y} = y^* - \varphi * (\pi - \pi *)^2$$

Here $\pi * \geq 0$ is the optimal inflation rate, which can be positive (if the positive effect of the labour channel prevails at a low inflation rate) or equal to zero (if the negative effect of the capital channel prevails at a low inflation rate);

$\bar{y}$ - long-term equilibrium (potential) level of output;

y^* is the long-term level of production can be achieved if the actual inflation rate is equal to the optimal $\pi = \pi*$.

V. CONCLUSION

The negative effect of the inflation rate on the welfare of economic agents was revealed, which is expressed in the fall in their equilibrium consumption level. Higher-income countries have been shown to suffer more from high inflation than poorer countries.

All conclusions made in the analysis of the dynamic model of the impact of inflation on potential output are verified based on econometric modelling using methods and models for panel data: models with fixed effects, models with random effects, and a generalized method of moments. Moreover, the obtained empirical results are stable concerning changes in the specification of the equation and estimation methods.

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